Climate Change and Variability, Its Impact on Rural Livelihoods, Local Coping and Adaptation Strategies in Woreilu *Woreda*, North Eastern Ethiopia

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Abstract

The study examines local climate change and variability situations, trends and impacts on the local adaptation and coping strategies in Woreilu Woreda.[1] It uses historically recorded temperature and rainfall, and household socio-economic data gathered from four kebeles[2], 8 villages and 154 rural households, which were analyzed using statistical tools and qualitative data analyzing techniques. The study revealed that the annual rainfall amount showed decreasing trend and increasing variability while temperature has, in general, increased. Drought has become more frequent and intense. As the local adaptation strategies become outdated, the people confronted with a situation that they are not sufficiently equipped to handle impacts of climate variability and change. Thus, the study suggests a relentless need to address these challenges both from short and long-term policy perspectives.

Keywords: climate change, climate variability, vulnerability, adaptation, coping strategy, trend, Woreilu

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Introduction

The problem of climate variability[3] and hence climate change[4] caused by natural and anthropogenic factors has become the challenge to the world. These days, people from all walks of life, international organizations, government and non-government organizations, and scientific communities have started feeling uneasy. As evidenced from the increasing global temperature and its consequences, climate change has become a reality (IPCC, 2001). However, it should be noted that 'world climates have changed in the geological past, are changing now, and there is every reason to expect that they will change in the future (Hobbs, 1980). Reports of the Intergovernmental Panels for Climate Change (IPCC) indicated that the earth's average temperature has increased by approximately 0.74^0c over the past century (IPCC, 2001). This is attributed to the accelerated burning of fossil fuels that contributed to the rise of major green house gases in the atmosphere, which has increased largely since the time of Industrial Revolution (1860), huge deforestation and land use and land cover changes resulting from rising population pressure (IPCC, 2007a; UNEP, 2008; Houghton, 1998; Cowie, 2007). The rise of global temperature, and associated consequences such as frequent and intense droughts, floods, rainfall variability, heat waves, storms and sea level rise have dramatically increased since 1970 (IPCC, 2001; Cowie, 2007; Houghton, 1989; Burroughs, 1997) and they will be more frequent and intense in the future as the rate of global warming is expected to increase in the future (IPCC, 2007a). Such climate change induced hazards affect both biophysical and socio economic systems in all continents and most oceans (IPCC, 2001), though the impact is more serious on the poor developing countries. Among others, the continent of Africa is highly vulnerable to climatic change impacts as the overwhelming majority of the population depends on natural systems that are sensitive to climate change and the incidence of non-climatic stresses that exacerbate vulnerability to climate change (UNEP, 2006; IPCC, 2001).

The impact of climate change and variability is severe on the agricultural sector, which is the main pillar of the economies of most developing nations. Rain-fed agriculture is the most common farming system in such regions (Rosell, 2010). This is also true in Ethiopia in general and Woreilu

Woreda in particular. Associated with the occurrence of EL Nino-Southern Oscillation that has greatly been frequent and intense consistent with global warming since 1970 (Houghton, 1998; Cowie, 2007; IPCC, 2007b), variability of precipitation, floods and drought have affected African agriculture (Obasi, 2005). The impact will be more severe in the future as its projected frequency increases (IPCC, 2007a). The impact is worse for peasants and farmers particularly those who have no opportunity to use irrigation. The effect is that if there is no rain in one year, there will be no food in the area (Orindi and Eriksen, 2005).

In Ethiopia, climate variability and associated hazards have left the country in precarious situation (NMSA, 1996b). Drought has affected Ethiopia for many years. Farming system in Ethiopia is, by large, rain-fed and is highly vulnerable to impacts of climate variability and change. A very small variation in the pattern of rainfall can cause crop failure. Rainfall failure means loss of major livelihood source that always aggravated food deficit situation.

Societies have inherently adapted to climatic impacts and have developed adaptation and mitigation strategies to tackle climate change and variability (IPCC, 2007b). However, the accelerated climate change and variability exacerbated by a number of socio economic factors (UNEP, 2006; IPCC, 2007b; Maddison, 2006) has become a challenge to the adaptive capacity of societies in countries like Ethiopia. Risks and uncertainties, often associated with seasonality, are typically agricultural practices, which in turn worsen vulnerability of the poor to food insecurity (IPCC, 2007b).

The highlands of Ethiopia, which mostly depend on crop production, are often affected by the current climate change. The problem becomes more serious in the north-eastern highlands of Ethiopia, which are more vulnerable to drought. It is in this region that Woreilu *Woreda* is situated.

The problem of climate variability and change is further exacerbated by extreme poverty, resource degradation that reduced the adaptive capacity of the society. As result of the fast changing climate, the previous coping and adaptive strategies[5] of the people have become inadequate. Although a few researches were made in a few localities of the country, particularly in the lowland areas (e.g. Aklilu and Alebachew, 2009; Assefa and Berhanu, 2008), it appears that there is a research gap in the north-eastern highlands of Ethiopia where climate change impact has been a threat to food security. The impact of climate change as well as the coping and adaptation strategies employed could differ because of varied socioeconomic factors and biophysical settings (Mendelsohn, 2000). They could also vary depending on the state of vulnerability[6] to climate variability and change. Such researches have limited importance in identifying area specific impacts and adaptation methods given the heterogeneity of regions in the country.

Even though the Federal Government of Ethiopia as well as the regional government of the area have set in place some initiatives to reduce the impact of climate change and variability, little attention was given to the knowledge of local climate change and adaptation and coping strategies. Thus, there is a need to assess and understand local climate change and variability impacts and associated adaptation and coping strategies of the north eastern highlands of Ethiopia to develop viable adaptation measures that will help people to co-exist with the changing climate (IPCC, 2007c).

Objectives

This article intends to assess the local climatic situation and trends of change and variability, and its impact on rural livelihoods. It also surveys perception of local people to climate change and variability and examines the local coping and adaptation strategies both at farm and household levels, and identifies factors that exacerbate peoples' vulnerability to climate change and variability. It also examines how much the existing coping and adaptation strategies are helping the local people cope and adapt to the climate change and variability.

Methodology

Materials and Methods

The survey is essentially micro level enquiry carried out at household and community levels to acquire data needed to assess the situation related to climate change and variability. In line with the objectives already set, various data collection tools including questionnaires, focus group discussions, interviews and field observations were used to gather data. Interviews were made with *Woreda* Agricultural and Rural Development (WARDO) workers and *Woreda* Disaster Prevention and Preparedness Commission Office holders to picture out their activities in assisting rural households to copping with climate change and minimize vulnerability to impacts of climate changes and variability. Moreover, focus group discussions were conducted with selected individuals in all sample villages. to pattern out local differences of people's experiences of climate change and variability and explore their perceptions.

Secondary data on socio-economic and demographic characteristics of the region were obtained from different *woreda* office records and Central Statistical Agency (CSA) reports. Data on crop failures due to climate change and variability, and rainfall and temperature data were obtained from *Woreda* Agriculture Rural Development Office and the National Meteorological Services Agency (NMSA), respectively.

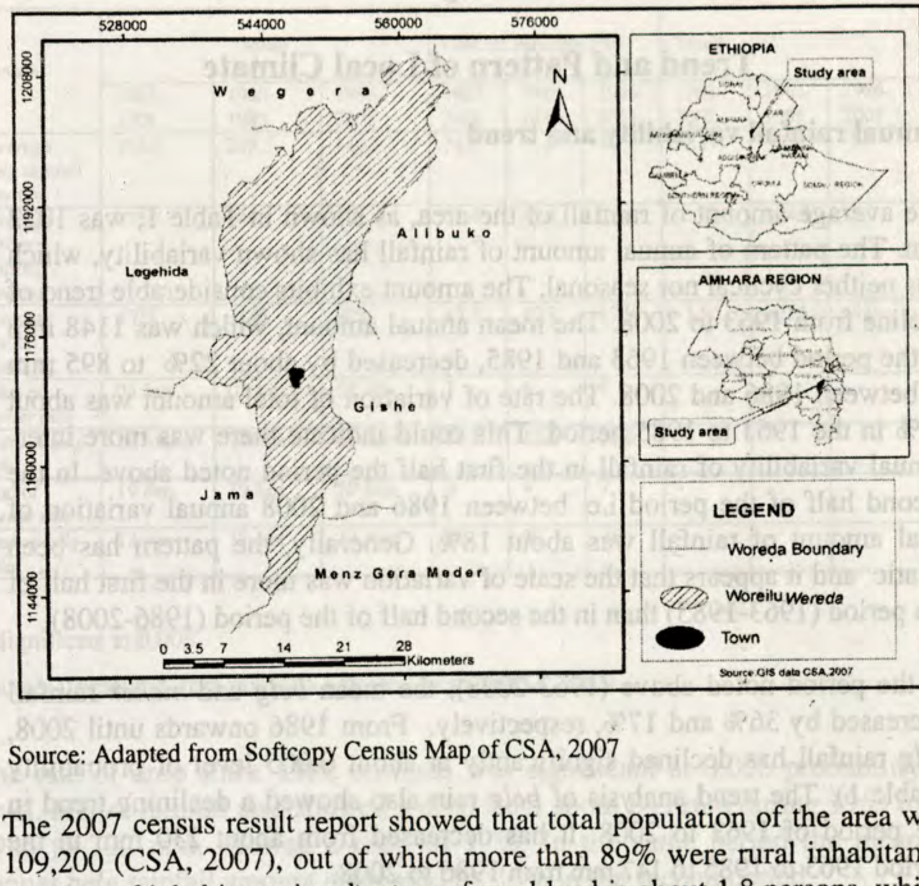
In order to gather primary data related to demographic and socio-economic characteristics including crop and livestock production, perception, adaptation and coping mechanisms to impacts of climate change and variability, structured questionnaires were administered in 154 selected rural households. To this effect four rural *kebeles*, three in *dega*[7] (Werebayasu, Harewa, and Danyu, which are *belg*[8], *meher* and both *meher* and *belg* producers, respectively) and one in *woina-dega* (Meni which is *meher* producer) were identified purposively and proportionally. Eight villages (*gots*), two each from the four rural *kebeles* were selected purposively by considering accessibility and cropping season diversity. *Dega* zone covers about 78% of the total area of Woreilu *Woreda*. A total of 154 sample *kebeles* were selected proportionally using lottery method from lists of tax payers and food aid beneficiaries.

The collected socio-economic and demographic data were summarized and analyzed using descriptive statistics, while data obtained from focus group discussions and interviews were processed using qualitative techniques. Rainfall and temperature data of 1963-2008 and 1992-2003, were statistically processed and summarized. Rainfall pattern was identified by comparing data of two periods, 1963 to 1985 and 1986 to 2008, to examine the changes in totals, seasonal distribution and variability. A time series analysis was used to compute the trend of annual, seasonal and daily rainfall and temperature data. The trend and variability of end of the rain, start of the rain and maximum dry spell length were performed using Instat+ v3.36 software. Variability of rainfall was identified using coefficient of variability and normalized rainfall anomalies. Metrological drought was analyzed using percentage deviation from the mean. The trend and pattern of rainfall was depicted on a time series graph, which is normalized.

The Study Area

The area selected for survey was Woreilu *Woreda*. It is found in South Wollo Zone of Amhara Region, north-eastern highlands of Ethiopia.The main urban centre of Woreilu Woreda is Woreilu, which also is the seat of *Woreda* administration. It is found at a distance of about 256 Km north of Addis Ababa. The region covers approximately 74,277.75 ha of land. Data obtained from WARDO showed that the relief of the region is heterogeneous and elevation ranges from about 1800 to over 3400 meter above sea level. Areas above 2400 meter above sea level cover 78% of total area of Woreilu *Woreda*. It consists of flat land characterized by gentle slopes and rugged topography. Vertisols which is locally known as *mererre* or *walka* predominantly covers the region. The *Woreda* has both *dega* and *woina-dega* type of climate although the former is more important. Annual total rainfall is about 1024 mm with high inter-annual variation. Most of the precipitation falls in *meher* season and small proportion of rainfall comes in *belg* season.

Figure 1. Location Map of Woreilu *Woreda*



Source: Adapted from Softcopy Census Map of CSA, 2007

The 2007 census result report showed that total population of the area was 109,200 (CSA, 2007), out of which more than 89% were rural inhabitants. Number of inhabitants in a hectare of rural land is about 1.8 persons, which roughly equal to 180 persons in a square kilometre area. The livelihood of the population highly depends on crop production. Data obtained from WARDO 2002 showed that crop production accounts for about 50% of income of the farming community. Livestock production also contributes 30% of the income sources and the rest comes from non-farm activities. As noted earlier, the *Woreda* is divided in to 20 *kebeles* or peasant administration units. The *kebele* peasant administration units varied in their harvesting seasons. Thirteen *kebeles* produce crops only in *meher* season while six *kebeles* produce both in *meher* and *belg* seasons. The remaining one *kebele* produces crops only in *belg* season. The Amhara Regional

Agriculture and Rural Development Office identified the area as one of food insecure *woreda* in the Amhara Region.

Trend and Pattern of Local Climate

Annual rainfall variability and trend

The average amount of rainfall of the area, as shown in Table 1, was 1022 mm. The pattern of annual amount of rainfall has shown variability, which was neither cyclical nor seasonal. The amount exhibits considerable trend of decline from 1963 to 2008. The mean annual amount, which was 1148 mm in the period between 1963 and 1985, decreased by about 22% to 895 mm in between 1986 and 2008. The rate of variation of total amount was about 41% in the 1963 to 1985 period. This could indicate there was more inter-annual variability of rainfall in the first half the period noted above. In the second half of the period i.e. between 1986 and 2008 annual variation of total amount of rainfall was about 18%. Generally, the pattern has been erratic and it appears that the scale of variation was more in the first half of the period (1963-1985) than in the second half of the period (1986-2008).

In the period noted above (1963-2008), the mean *belg* and *meher* rainfall decreased by 36% and 17%, respectively. From 1986 onwards until 2008, *belg* rainfall has declined significantly at about 0.005 level of probability (Table 1). The trend analysis of *belg* rain also showed a declining trend in the period of 1963 to 2008. It has decreased from about 230 mm in the period 1963 to 1985 to 147 mm from 1986 to 2008.

Table 1. Seasonal pattern of rainfall at Woreilu Station

Season	Mean			Coff. of variation (%)			Trend		
	1963-2008	1963-1985	1986-2008	1963-2008	1986-1985	1986-2008	1963-2008	1963-1985	1986-2008
Average *belg* rainfall amount	188.1	229.5	146.5	74.3	71.8	46.3	-2.17	+9..9	-5.9
Average *meher* rainfall amount	775.7	849.1	702.4	51.4	43.4	9.66	-0.73	+24.6	-7.9
Average annual rainfall	1022	1148	895	47.2	40.7	17.9	-3.5	+35*	-3.0
Start of *meher* rain	05 July	02 July	08 July	7	6	7	-	-	-
Start of *belg* rain	26 March	19 March	01 April	54.7	53.3	56.6	-	-	-
End of *meher* rain	19 Sep	19 Sep	20 Sep	4	4	7	-	-	-
End of *belg* rain	13 Apr	12 Apr	14 Apr	36	37	36	-	-	-

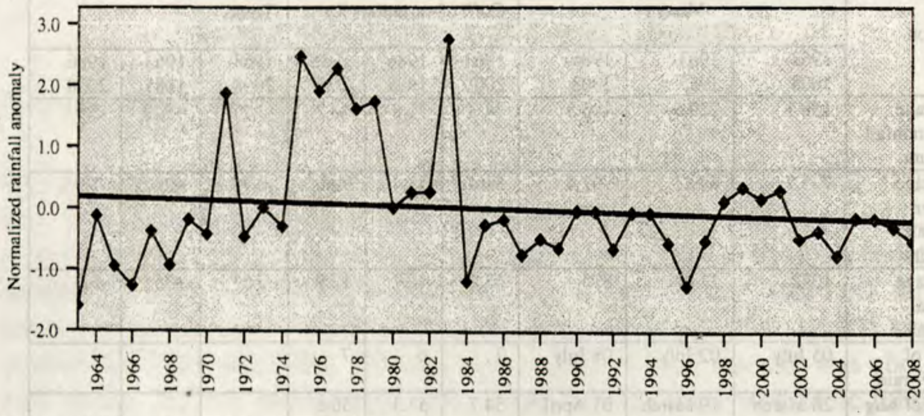
* Significant at 0.005

Source: Computed from raw data obtained from NMSA, 2010

The rate of drop since 1986 onwards was significant at 0.006 probability level. *Meher* rainfall also showed a drop from about 849 mm during 1963 to 1985 to 702 mm, showed a drop of 17%. In the same period the mean annual *belg* rainfall amount decreased by 36% in the second period.

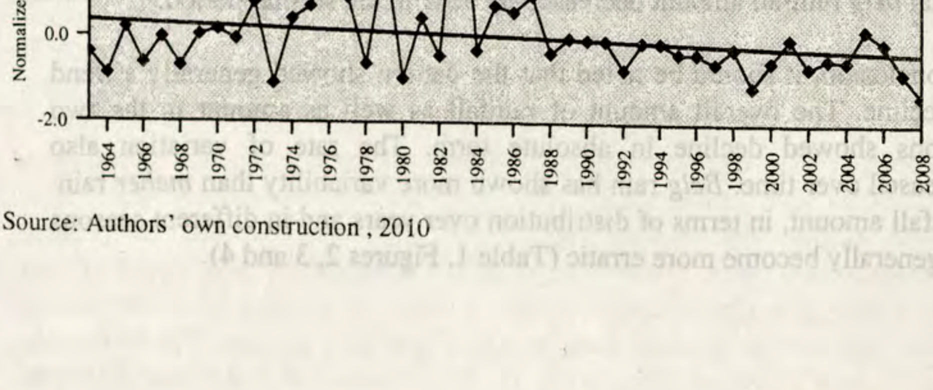
In conclusion, it should be noted that the pattern showed generally a trend of decline. The overall amount of rainfall as well as amount in the two seasons showed decline in absolute term. The rate of variation also decreased over time. *Belg* rain has shown more variability than *meher* rain. Rainfall amount, in terms of distribution over years and in different seasons has generally become more erratic (Table 1, Figures 2, 3 and 4).

Figure 2. Variability and trend of annual rainfall at Woreilu expressed in terms of normalized rainfall anomaly



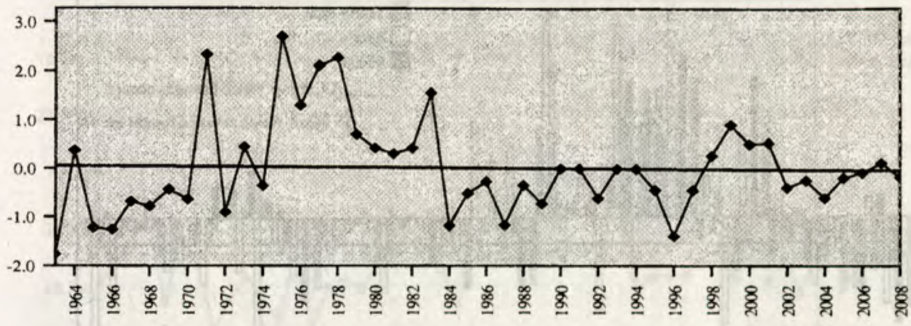
Source: Authors' own construction , 2010

Figure 3. Variability and trend of *belg* rainfall at Woreilu expressed in terms of normalized rainfall anomaly



Source: Authors' own construction , 2010

Figure 4. Variability and trend of *meher* rainfall at Woreilu expressed in terms of normalized rainfall anomaly



Source: Authors' own construction, 2010

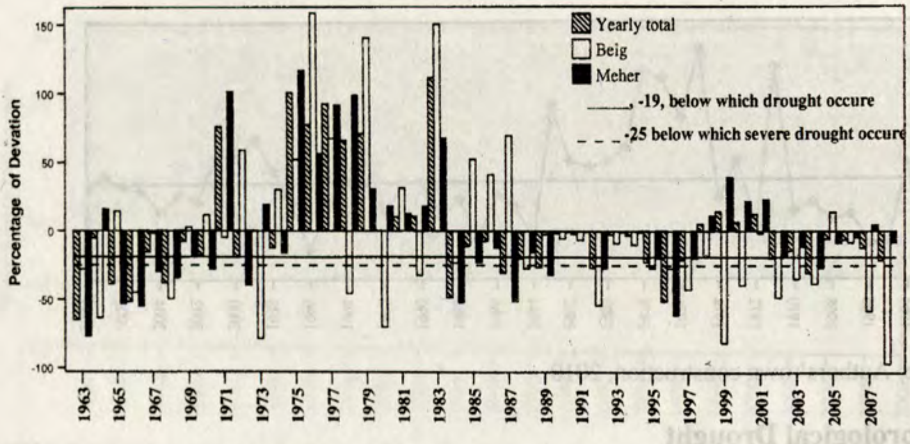
Meteorological Drought

The National Metrological Service Agency (NMSA) of Ethiopia defined metrological drought years based on seasonal rainfall anomaly. According to NMSA (1996a), drought occurs over a region if the negative anomaly from the mean seasonal rainfall is 19% or more, but less than 21%. Furthermore, drought is classified as moderate and severe if the seasonal rainfall deficiency is between 21 to 25% and more than 25%, respectively.

Based on the drought classification report of the National Metrological Service Agency (NMSA) of Ethiopia, the survey result showed that the region experienced a number of drought years. The frequency and intensity of drought was higher in *belg* season than in *meher*. In the period 1963 to 1985 nine severe and one moderate drought occurred in *belg* season while the rate of occurrence was seven severe and one moderate in *meher* season in the above noted period. However, from 1986 to 2008 the severity and frequency of *belg* drought has increased as 13 severe droughts occurred within the period. In the same period, only four severe droughts occurred in *meher* season.

Generally, one can see from Figure 5 that the frequency and severity of drought has increased in *belg* season but it decreased in *meher* season over the recent 20 years (1986-2008) of the study period.

Figure 5. Percentage of deviation of annual total *meher* and *belg* rains between 1963 and 2008

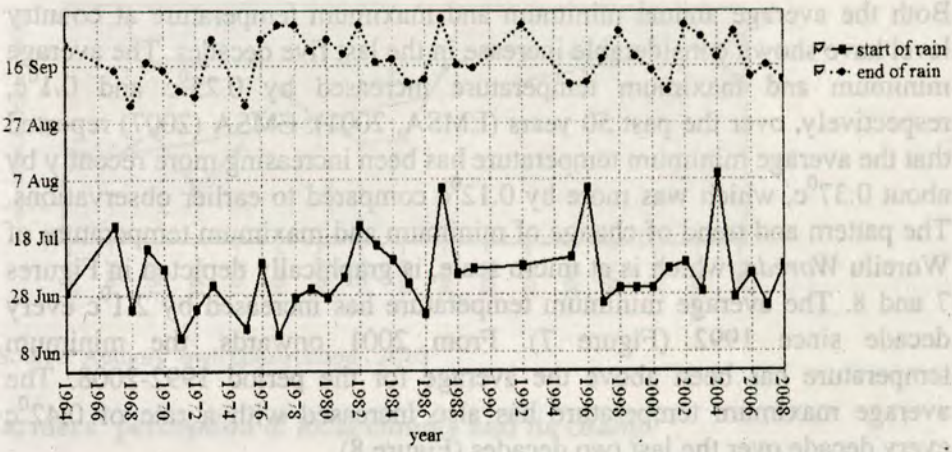


Source: Authors' own construction, 2010

Pattern and variability in the start and end of rain

In the analysis of start and end of rain as well as maximum dry spell, the 1963 data was not included as September data and the first 10 days of July data were missing from the recorded data. The average date of start and end of the rain fluctuated between the two periods, 1964 to 1985 and 1986 to 2008 (see Figure 6). The average starting date, which was 02 July during 1964 to 1985 shifted to 08 July during 1986 to 2008. In the same period, the average starting date of *belg* season shifted from 26 March to 01 April. Variability for the start and end of the rain is higher in the small rainy season than the main rainy season. The coefficient of variability for the start of the rain was more than 50% for the *belg* season but it was less than 7% for *meher* season.

Figure 6. The onset and end of *meher* rainfall in Woreilu, from1964 to 2008



Source: Authors' own construction, 2010

Length of maximum dry spell

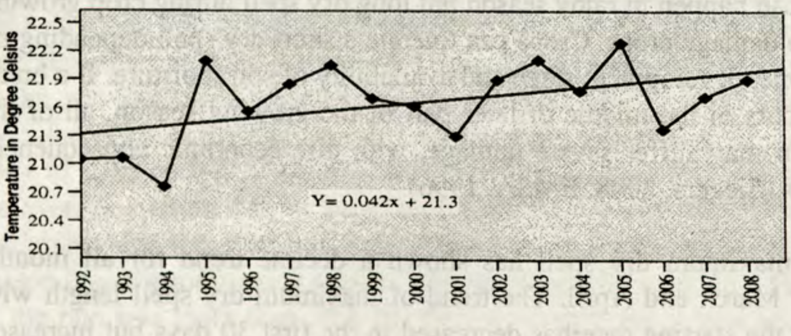
Dry spell can happen in rainy season but long dry spell during crop growing season can damage crops. Crops can tolerate a short dry spell depending on the crop type, development stage and availability of soil moisture. If a break of rain occurs in the middle or later part of the growing season, all of the crops sown may suffer severe damage, with dire economic consequences for farmers (Slegers, 2008; EMSA, 1996).

Trend of maximum dry spell has shown a decline trend for all months except for March and April. The trend of maximum dry spell length with relative to the starting date has decreased in the first 30 days but increased in the 60 days after sowing date during 1964 to 2008. After sowing date, in the first 30, 60 and 90 days, the maximum dry spell increased during the period from 1964 to 1985 but decreased during 1986-2008. From 1986 to 2008, a significant decrease of maximum dry spell length was observed for the first 90 days.

Trend of temperature change and variability

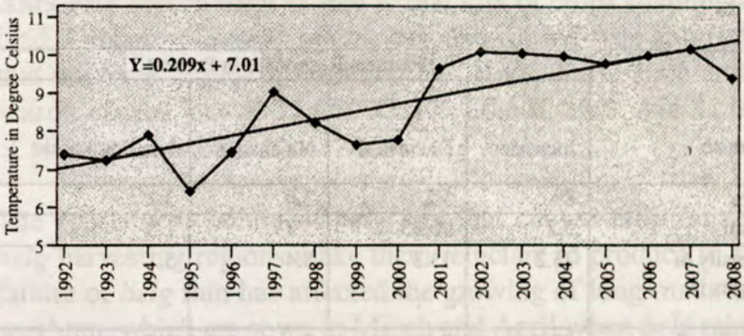
Both the average annual minimum and maximum temperature at country level have shown considerable increase in the last five decades. The average minimum and maximum temperature increased by 0.25^0c and 0.1^0c, respectively, over the past 50 years (EMSA, 2001). EMSA (2007) reported that the average minimum temperature has been increasing more recently by about 0.37^0c, which was more by 0.12^0c compared to earlier observations. The pattern and trend of change of minimum and maximum temperature of Woreilu *Woreda,* which is at micro scale, is graphically depicted in Figures 7 and 8. The average minimum temperature has increased by 2.1^0c every decade since 1992 (Figure 7). From 2001 onwards, the minimum temperature has been above the average for the period 1992-2008. The average maximum temperature has also increased with a rate of 0.42^0c every decade over the last two decades (Figure 8).

Figure 7. Trend and variability of annual maximum temperature in Woreilu *Woreda*



Source: Authors' own construction, 2010

Figure 8. Trend and variability of annual minimum temperature in Woreilu



Source: Authors' own construction , 2010

Farmers' perception of local climate and its change

The farmers of the area, as confirmed by their responses, which is summarized in Table 2, are aware of the fact that the local climate has been changing as compared to the situation in the past. Most farmers (89%) noted an increase in temperature over the past 17 years. They also perceived that rainfall has decreased considerably and became more unreliable (variable) as compared to the situation in the past. They reported that rain starts late and stops earlier as compared to past experiences. Farmers also became aware of an increase in the maximum dry spell length during wet season. They complained that there was failure of *belg* rain in the recent past. They reported that the amount of *belg* rainfall declined over the past 20 years and totally failed since 2007 to the present. Their observations were attested by recorded data (Table 1 and Figure 5). The farmers in the *meher,* and *belg* and *meher* producing areas experienced early cessation of rain, annual and monthly rainfall variability and erratic rainfall during harvesting season as their major challenges.

Table 2. Percentage distribution of farmers' responses about their perception

Local climate	Farmers Responses in Percent			
	Increased	Decreased	No change	I do not know
Average temperature	89	5.2	2.6	3.2
Average total rainfall	5.2	90.25	3.25	1.3
Frequency and intensity of occurrence of droughts in *Meher* season	73.2	13.3	8.4	5.1
Frequency and intensity of occurrence of droughts in *belg* season	97.4	0	0	2.6
Change in the frequency of rainfall irregularities				
Early cessation	66.2	11	14.9	7.8
Late onset	61.1	16.9	16.2	5.8
Dry spell for some days in the wet season	56.5	9.7	12.4	21.4
Un-seasonal rainfall during harvesting season	8.4	78.6	3.9	9.1
Heavy rain in meher season	11.7	67.5	7.2	13.6

Source: Field survey, 2010

Impact of Climate Change and Variability on Crop and Livestock Production

Impact on crop production

Undesirable impacts of climatic change and variability on crop production system seem not something new in the study area. Metrological drought including early cessation and late onset, heavy rain and frost has caused crop production loss.

Drought in the region has caused crop failure in both *belg* and *meher* seasons. However, the impact has become more serious in the *belg* season because it caused total crop failure since 2006. According to the *Woreda* Agricultural and Rural Development Office (WARDO) of Woreilu about

80%, 73%, and 83% crop production loss was reported in the *belg*-cropping season of 2002, 2004 and 2007, respectively. The droughts during 2008 and 2009 *belg* season have caused a total loss of crops sown on 785.5 hectare of land. Drought in *meher* season has also caused crop shortfall. The droughts that occurred in the *Woreda* in 1997, 1998, 2001, 2002 and 2007 in *meher* season caused loss of 73.6%, 23.3%, 30.6%, 39%, and 31.05 % production of all crops, respectively.

The subsequent failure of *belg* rain that caused crop failure in *meher* and *belg* harvesting regions make them reluctant to produce in *belg* season. The failure of *belg* rain has affected the growing of long maturing crops such as sorghum, which are sown in March and April when *belg* rain is available.

Early cessation of rain has caused production loss. The *meher* harvesters complained that early cessation has become more frequent. Accordingly, during 2007 the rain ceased early and caused outbreak of crop diseases and pest that have resulted in loss of crop production. The delay of onset of rain has spoiled the dry planted crops. In the *woina-dega* areas, farmers plant crops such as faba bean, field pea and barley (*ginbotie gebis)* in late May or early June as dry planting. For example, the rain delay in 2004 spoiled germination of dry planted crops. Recent drought in *belg* season that hampered crop production left the *belg* harvesters in a precarious condition.

It is not only drought that caused crop production loss but heavy rainfall also adversely affected crop yield (production) and damaged production. In the *Woreda,* where 90% of the soil is Vertisols, heavy rain during *meher* season affects land preparation, seed germination and caused loss of production. Recorded production losses by the WARDO are indications of occurrence of heavy rain in 1996, 1998, and 2001, which caused loss of 17%, 60%, and 22.4% of crops.

Frost is another climatic problem that has caused crop loss in the *Woreda.* Frost has occurred in the area in 2007 and 2008 in *meher* season and caused 12.4 %, and 33.5 % of crop production respectively. The damage reaches up to 100% for some crops such as *teff* in the localities of Tulusertu and Meni. From the total surveyed respondents, 62.3 % attributed the damage to frost.

The frequent drought in *belg* season has adversely impacted land tillage. Land tillage using oxen before the onset of *meher* rain, which is locally known as *Gemesha,* became difficult in drought years because Vertisols become very hard and difficult to work on during the dry season. In heavy rain years, owing to stickiness of the Vertisols, ploughing of land using oxen again is difficult. The impact of the problem of heavy rain on land preparation has exacerbated by the lack of oxen, where by more than 24% of the households lack oxen, exacerbated the problem of crop cultivation.

Impact on livestock production

Livestock production is based on stall-feeding on crop residues and other prepared fodder. Result of focus group discussion and interviews held with WARDO experts showed that drought and delay of the onset of rain led to poor grass regeneration, forage scarcity, water shortage and heat stress on livestock. This has consequently increased mortality rate of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures. Local elders and respondents reported that in drought years livestock were underfed and their productivity decreased because of lack of pasture.

About 21% of the respondents reported that during the drought years they were forced to buy animal fodder from distant places such as North Shewa using their pack animals. The consecutive drought years have caused shortage of fodder and forced farmers to reduce the number of their livestock. About 7.5 % reduction in livestock size was reported at present as compared to past 20 years. The reason for declining livestock number as reported by 53 % of the respondents was shortage of fodder. However, about 47% of the respondents attached it to economic problems. Fodder scarcity could be triggered by frequently recurring drought and grazing land scarcity, which was caused by increased stocking and human population densities in the area.

Impact of drought on water availability

The prolonged drought caused seasonal drying up of streams and springs, which are used as sources of water used for both humans and livestock. Drought of *belg* season in 2007, 2008 and 2009 caused drying up of smaller streams and springs, which were used previously to water cattle. As a result farmers were compelled to take their livestock to distance places where water is available. The distance their livestock travel varies amongst the sample villages depending on their position relative to the location of the streams.

Benefits of climate change on crop production

In Woreilu Woreda, specifically in Worebayasu *kebele* peasant administration unit, crop cultivation has been carried out only in the *belg* season because cold temperature of *meher* season disallows crop production. Although it was not as productive as the *belg* season, farmers recently started cultivating crops in some of their farms in the *meher* season. This may be partly due to rising trend of temperature that enabled crop production in *meher* season in *dega* zone, where temperature used to be very low. The other reason could be continuous failure of *belg* rain. This has forced farmers to cultivate crops in the *meher* season. Temperature increase shall tend to strengthen the growing season in *meher* and shall enable crop cultivation in the *belg* producing localities.

Impacts of climate change and variability on the society

Drought, frost and heavy rain have caused crop production shortfall. As the livelihood of the population depends on crop production, failure of crop has resulted in food insecurity to most households. Food insecurity caused by production shortfall forced the people in the region to depend on relief aid, consume low quality foods and reduce the amount of consumption during bad years. For example, during the year 2003, 2008 and 2009 about 60,200 (approximately 55.7% of the total population), 21,555 and 26,886 people respectively depended on relief aid to sustain their lives. During 2007 and 2008, about 71,172 (about 65%) of the total population in the *Woreda* were exposed to food insecurity resulting from production shortfall (WDPPC, 2009). The households were also forced to sell their livestock, borrow money or grain, and engage more on off farm activities to ensure food security over the past 20 years. Such survival strategies may lead to further depletion of household assets.

Local Coping Strategies and Adaptation to Climate Change and Variability

Agronomic adaptation and coping strategies

The farmers in the study area have practiced different agronomic adaptation strategies for a long period, as climatic variability has been common phenomenon in the area. The local agronomic adaptation strategies include sowing variety of crops, planting early maturing plants, growing drought resistance crops, shifting harvesting season from *belg* to *meher* season, re-sowing (replanting) and adjusting agricultural practices. Some of these adaptation and coping strategies have been challenged by the changing climate and are less commonly used as drought becomes more frequent.

Through experience, the farmers have established own cropping calendar and know the right date of sowing. The farmers sow early when they feel that the rainy season is approaching to use the rainfall effectively and sow late when their plot becomes waterlogged. Farmers decide what crops to grow in accordance with the conditions of the rain. Farmers grow *teff* if they foresee that the rain is heavy and wheat and other drought resistant crops when they suspect that the rain is going to be light. However, in most cases, the farmers are not sure about the rainfall condition even after the onset of rain. Thus, the farmers plant a variety of crops such as teff, wheat, beans, etc. instead of growing a single crop to minimize risk of crop failure due to climatic variability. Because of poor access that many farmers have to climatic and metrological information, coping with impacts of climate variability and change by adjusting their traditional agriculture calendar has become less efficient.

Farmers plant early maturing crop varieties to adapt to rainfall insecurity, and to meet food security early in the next harvesting season. Farmers sow early maturing *teff* variety locally known as *bunign.* However, they explained that *bunign* is not as productive as other *teff* varieties such as *magna* and *enat teff, which* are common varieties in the area.

These days drought recurs more often and it is prolonged. Therefore, farmers of the area grow drought resistant and fast-maturing crops. Moreover, in recent years, some of the farmers have tried to shift their harvesting season from *belg* to *meher* because *belg* rain has become more variable and unreliable, and even sometimes totally fails. Yet, they reported that the situation seems not promising.

Some farmers (21.4% of the respondents) participated in small-scale water harvesting techniques. However, water collection and redistribution to crops was challenging. Farmers reported that such type of water-harvesting systems affect the size of their farmland. They reported that such adaptation strategy was found not affordable because of increased labour and land, shortage of capital required for the activities. Because of this, they disregarded using such type of water harvesting system to combat water shortage.

Farmers have developed agronomic coping strategies. They have practiced re-sowing of another crop whenever they encounter crop failure at its early stage. This method was practiced by about 76% of the respondents. Farmers did make use of such opportunities by planting the second crop at earlier stage wherever possible. The focus group discussants of *meher* harvesters also reported that they re-planted other crops such as chickpea and grass pea to recover the loss of crop. However, such readjustment is possible if the damage done is at the earliest stage of the growing period and sufficient moisture is available in the soil for growing the second crop.

Diversification of income sources

Diversification of household sources is the strategy mostly practiced in areas with low and erratic rainfall as a way to overcome climatic risk (Elfaig and Serdang, 1999; Kebebew *et al.*, 2001 as cited in Slegers, 2008). Some households reported that they further diversified their household income sources by engaging more in livestock production, petty trading, handicraft and other activities as compared to the previous years. However, about 73% of the respondent households reported that their means of income diversification have not shown change as compared to the past 15-20 years.

Coping strategies to meet food security

A significant proportion of the population of Ethiopia lacks access to adequate food at all times for an active and healthy life. The food insecurity situation in the rural part of the country is appalling where about 52% of the entire rural population does not have access to adequate food (Yared, 2001). Such food insecurity situation becomes even worse when there is production shortfall caused by climatic vagaries. Rainfall failure caused socio-economic problems (Shanko and Chamberlain, 1998) and loss of major livelihood source that always accentuated food. As food insecurity is a regular feature in many households, they may employ coping strategies to ensure food availability or increase the source of income even in normal years. However, unlike in normal years, households may be forced to employ coping strategies, which were not common in a normal year and/or may increase their involvement on those coping strategy activities that were developed during the other abnormal years.

Depending on the intensity and frequency of the disaster, households employed different coping strategies in different bad years. One of the coping strategies practiced by many farmers was consuming lower amount and quality food as means to extend available meagre resources for a longer time until the next harvest season or get another means of survival. Selling livestock is another coping strategy practiced relatively higher and middle income groups. About 49 % of the households sold their livestock to buy food in bad years over the past 20 years. However, the households reported that the price of livestock decreased in the bad years and they were forced to sell at lower prices. In contrast, grain price rose up in those years. Households use loan in the form of money or grain to meet their food security. Loan has put pressure on the recovery of the poor because of high interest. For example, in 2008 some households faced food shortfall as a result of crop damage caused by frost. During this year, the rich households lent two *quna* grains (equivalent to 20kg) to be paid back as three *quna* (30kg). In bad years, the poor extend the duration of their involvement in seasonal labour migration and increase the number of family members who engaged in it.

The government has provided relief aid and launched Safety Net Program (SNP) to distribute food aids during production shortfalls and assisted selected farm households to attain food security in normal years. In 2003 about 60,200 (approximately 55.7% of the total population) have received relief aid. Due to inadequate relief supply, out of the 71,172 people that were exposed to food shortage only 21,555 and 26,886 people had received relief aid in 2008 and 2009, respectively (WDPPC 2007). The government launched a SNP in 2005. About 28.4% of the total population benefited from the program. The household survey also revealed that about 29% of the sample households were beneficiaries of the SNP.

Sources of vulnerability to climate change and variability

Different socio-economic factors can exacerbate impacts of climatic change and variability and undermine the adaptive and coping capacity of households. The survey identified some socio-economic factors that exacerbated peoples' vulnerability to adverse climatic impacts:

Poor access to meteorological information

Access to information concerning climate change and variability forecast, adaptation options and improved agricultural production activities remain an important factor affecting use of various adaptation measures for most farmers (Nhemachena, and Hassan, 2007; Nhemachena and Hassan, 2008; Glwadys, 2009; Temesgen, 2007). Access to information about climatic variability and early warning system can reduce the damage caused by climate change hazards (IPCC, 2007b; NMA, 2001). It was found that most farmers in the study area do not have access to metrological information. This may be due to low level of literacy because only about 48 % of the respondent households were literate. The other reason could be lack of source of information. With the exception of weather information some farmers get from other experienced or knowledgeable farmers, more than 90 % of the sampled households lack access to information. This could have imposed a challenge on adjusting crop type and sowing calendar to climatic variability. Such poor access to climatic information hinders farmers' adaptation to climatic variability (Temesgen, 2007; Maddison, 2006).

Table 3. Some factors that exacerbate households' vulnerability to impacts of climate change

	Respondents	
	No.	(%)
Possession of Oxen		
None	38	24.7
One Ox	36	23.4
Two Oxen	59	38.3
Three Oxen	21	13.6
		100
Access to Credit		
Have access to modern financial institutions	135	87.6
Have access to traditional financial institutions	101	65.5
Access to Meteorological Information		
Have access to climatic and meteorological information originated from NMSA	8	5.2
Have access to weather information from other experienced or knowledgeable farmers	149	94.8
Access to small-scale irrigation		
Have access to irrigation	0	0
Have no access to irrigation	154	100

Source: Field survey, 2010

Poor status of households and poor technical support

Lacks of access to facilities and material recourses, which can arise from poor status of households, are conditions that accentuated vulnerability to climatic vagaries. Ownership of oxen is vital to carry on agricultural activity on time. Hence, ownership of a pair of oxen is taken as an indicator of attainment of independent and self-reliant household (Yared, 1999).More than 24% of the sampled households (Table 3) do not have oxen for ploughing the land. Lack of oxen can adversely influence households' potential to plough their land at the most possible optimal time. The area is one of the food deficient *weredas* in South Wollo Zone. More than 35% of the sample households were food insecure even in normal years. Thus, such food insecurity in a normal year would be aggravated during bad years.

Crop production in the woreda highly depends on rainfall that comes during *meher* and *belg* seasons. Because of topographic situation and scarcity of surface water resources which arise from erratic nature of rainfall pattern, there is little or irrigation practice. Lack of irrigation system coupled with the absence of higher value crops that can serve as sources of income and/or food exacerbated the food shortage situation in bad years.

Access to affordable credit increases the financial resources of farmers and their ability to meet transaction costs associated with the various adaptation options. Research findings by Glwadys (2009), Temesgen (2007), and Nhemachena and Hassan (2007) showed that farmers with access to credit have better chance of adapting to the changing climatic conditions. It was found that 88% of the households of the study area have access to formal credit from financial institutions. However, the amount of money that farmers could access is only 500 birr per person in the first round. Such small amount of money may not be adequate enough to undertake adaptation measures. Besides, the beneficiaries need to pass through lengthy bureaucratic procedure to collect the money, which is demanding long time.

The government has put in place agricultural extension services and assigned development agents in rural areas. However, such services in Woreilu *Woreda* could not sufficiently address the problems that arise because of climate change and variability. The extension services mostly aimed at maximizing agricultural productivity but not directly linked to adaptation to climatic change and variability.

Conclusions and Recommendations

Conclusions

The observed changes and variability of the climate in the survey area at local scale is only part and parcel of the ongoing global climate change. The study showed that there has been change in the patterns of local temperature and rainfall. Temperature has been increasing and the amount of rainfall has been decreasing. Irregularities in the pattern of rainfall have been increasing and drought has become more frequent and intense.

Climate variability and change have posed adverse effects on crop and livestock production and consequently to food shortage in the area. The consecutive failure of *belg* rain in the period 2007-2009 has greatly affected the *belg* harvesters. Although the gradual temperature change is fostering crop cultivation in *meher* season in the *dega* areas, climatic variability and change is likely to continue to constrain crop and livestock production and consequently cause food shortage to households.

Rural households in the study area have been coping with various types of pressures on their livelihoods for many years. The local adaptation and coping strategies have been the key to survival. However, the ever-increasing climate variability and change have challenged the traditional and local coping and adaptation strategies and proved less efficient. Support from the government in the form of relief aid and Safety Net Programme, though not adequate, can contribute to people's recovery but may not be a lasting solution to adapt to the changing climate. As some of the indigenous coping and adaptation strategies have become less efficient, it seems that there are no appropriate policy measures in place that can help people to get acquainted with appropriate and efficient adaptation strategies.

Recommendations

Local adaptation and coping strategies are becoming old-fashioned to cope with and lessen climate change and variability, and their impacts. Hence, this would require institutional involvement, integrated and relentless effort to improve livelihoods survival strategies of the people. As droughts become more frequent and more harmful to the economic life of the *belg* harvesters, further intervention through adoption of short-maturing crops that can withstand cold temperature in *meher* season is required. It is advisable to promote access to efficient micro finance provision and other SNP benefits that would reduce the effect of shocks from crop failure.

As the households of the area operate under rainfall uncertainty, early warning of any considerable change in rainfall patterns and drought forecast information could assist farmers to make adjustments, cope with or adapt to the changing conditions. Some of the agronomic coping strategies that are in place were challenged, by the ever increasing climate change and variability. Therefore, other long term adaptation and coping strategies should be promoted. Farm household heads of the area should be encouraged to adopt more drought resistant, short-maturing crops, and use more moisture conservation strategies such as water harvesting technologies, and develop small-scale irrigation schemes to combat adverse effects of drought. It is also wise to introduce high value tree crops, and agro-forestry practices. Concerted efforts should be made to diversify household livelihood strategies by promoting off-farm activities such as petty trading and handcrafts.

In order to improve adaptive capacity and increase agricultural yield, concerted efforts should be made to deal with problems related to climate change and variability, land degradation and loss of biodiversity and ecosystem services.

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Endnotes

[1] Administrative unit, which is probably equivalent to a district

[2] *Kebele* is an administrative unit at grassroots level.

[3] Climate variability refers to variations in the mean state of climate on all temporal and spatial scales beyond that of individual weather events. Examples of climate variability include extended droughts, floods, and conditions that result from periodic El Niño and La Niña events.

[4] Climate change on the other hand refers to shifts in the mean state of the climate or in its variability, persisting for an extended period (decades or longer). Climate change may be due to natural changes or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

[5] Coping strategies (responses) are the collection of short-term responses to potential impacts that can be successfully applied season-to-season or year-to-year as needed to protect a resource, livelihood, etc. Some forms of coping are explicitly anticipatory and take the form of, for example, insurance schemes and emergency preparedness. Adaptive responses, on the other hand, refer to the ways individuals, households, and communities change their productive activities and modify their rules and institutions to minimize risk to their resources and livelihoods. Depending on the frequency, duration, and suddenness in the onset of a stress, and on the resilience of a system, either coping or adaptive responses or both will come into play. With a progression of change in climatic conditions, coping mechanisms may at some point be overwhelmed, and by necessity supplanted by adaptive responses.

[6] Adaptive responses, on the other hand, refer to the ways individuals, households, and communities change their productive activities and modify their rules and institutions to minimize risk to their resources and livelihoods. Depending on the frequency, duration, and suddenness in the onset of a stress, and on the resilience of a system, either coping or adaptive responses or both will come into play. With a progression of change in climatic conditions, coping mechanisms may at some point be overwhelmed, and by necessity supplanted by adaptive responses.

[7] *Dega* and *woina-dega* are traditional elevation-temperature zones.

[8] There are 20 rural kebeles in the region. 14 of these, which cover 78% of the area are found in *dega* zone and the rest in *woina-dega* zone. Three cropping seasons - *meher, belg-meher and belg* are identified in the area. *Meher* overlaps with the main wet season of June, July and August, *belg,* small rainy season, stretches from March to May, while *belg-meher* extends from March to September.